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The Journal of HEREDITY

Thomas Andrew Knight

——Reported dominance in peas when Mendel was a babe

VOLUME 21 DECEMBER, 1930 NUMBER 12

The American Genetic Association

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FREESIAS WILD AND DOMESTICATED

Frontispiece

Two views of a South African Freesia species (at left) and a recently introduced white variety (Elder's Giant White) showing their relative sizes. The giant form is a mutation which appeared among a group of seedlings.

FLOWER FORMS IN HYBRID FREESIAS

W. P. Morgan

Indiana Central College, Indianapolis, Indiana

IT is reasonable to expect a greater interest in the history of the hybrid Freesias now that their commercial importance is well established. Some idea of the growing popularity of this fragrant flower may be gained from the fact that approximately twenty million corms are purchased annually by florists in this country for forcing under glass. Although there has been little united effort to popularize the Freesia it has continued to grow in favor and an ever increasing number of flower lovers are learning to know its pleasing fragrance and subtle beauty. The demand for Freesia blossoms in our larger cities during the months of January, February and March makes this plant one of the important items in the florist trade of our country.

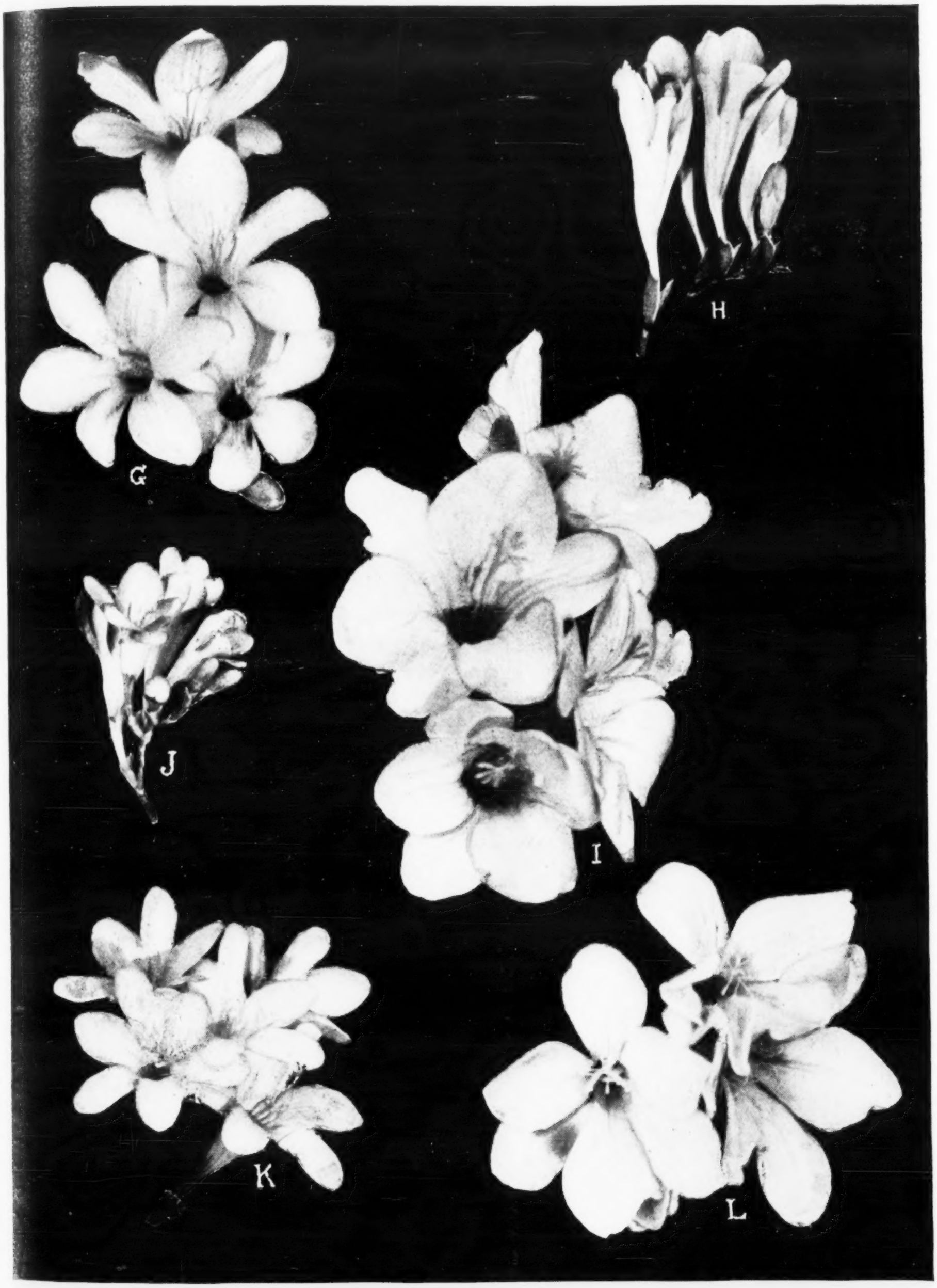
High-lights in the Freesia's history begin with its importation into England from South Africa. This probably took place in 1816 since it was first illustrated in the Botanical Register of that year. (Figure 3.) The commercial introduction of a white variety with a distinct orange-yellow blotch (*Freesia refracta alba*), in 1878 by the New Plant and Bulb Company of Colchester, England, paved the way for the present popularity of the Freesia and this variety remained *the* Freesia until the introduction of the white American variety 'Purity' by the late Rudolph Fischer in 1905. (Figure 4, *B*.) Serious efforts by hybridists to improve the Freesia date from about 1878, or following the discovery of a large yellow variety known as *F. leichtlinii* in a neglected Italian nursery by the late Herr Max Leichtlin. Varieties of minor importance resulted from the *refracta alba* and *leichtlinii* crosses. Most of these were white and pale colors, especially in shades of yellow. Probably the greatest event in the history of the modern Freesia took place in 1905 when the pink species (?) *F. armstrongii,* which had been found near Humandsdorp, South Africa, was obtained in sufficient numbers to supply the hybridists in Europe and America. Some of the men who saw the possibilities in crossing *F. armstrongii* with *refracta alba* and *leichtlinii* were the workers at Kew Gardens, England, Dr. A. Ragionieri of Italy, C. G. Van Tubergen of Holland and Dr. Walter Van Fleet in America. From the results of these crosses we have all the many colored Freesias ranging through light yellow to orange, blush pink to flame red, pale mauve to deep lavender, brown and varigated. Accompanying these color changes have come variations in the form of the flowers which are equally interesting. It is to some of these flower types selected from a large mass of seedlings that the writer wishes to call attention. Although the parentage of these Freesias is unknown it has been definitely ascertained that they have arisen from intercrossing (bee pollination) the seedlings obtained from random crosses among the few commercial varieties available a decade ago.

In a recent number of the JOURNAL OF HEREDITY attention was called to a large flowered Freesia variety which had appeared in a group of seedlings at the establishment of Elder Brothers at Indianapolis, Indiana. This mass of seedlings numbered several thousand and contained many variations in flower form which were quite distinct from any of the commercial varieties. Several of the most interesting flower types were selected and their stocks increased. (The remainder were destroyed.) Several of these selections are shown in the accompanying photographs. Some of these seedlings offer little, if any, com-

VARIATION IN FREESIA SEEDLINGS

Figure 1

A group of flower types selected from a large mass of Freesia seedlings. *A* and *B* are slightly more reduced than the other flowers in this figure.



OTHER HYBRID FREESIA TYPES

Figure 2

Additional types from the series of seedlings illustrated in Figure 1. The flowers shown at *I* and *J* illustrate extremes in size. The tubular corolla of the original wild freesia is closely approximated in the type shown at *H*. (See Frontispiece and Figure 3.)

mercial possibilities and are shown only for the purpose of portraying the great range of form available in the blossoms of hybrid Freesias. None are named varieties (with the exception of those shown in Frontispiece and in Figure 4, *B*), although all are carried under number and part have been used in some of the many recorded crosses made by the writer. It is possible that a few of these types may be similar to those mentioned in the writings of the late Rev. Joseph Jacob of England, Dr. Ragionieri of Italy and the late Dr. Walter Van Fleet of the United States.

Although the usual Freesia flower has six floral segments, in Figure 1 *B* a flower cluster is shown with a greatly increased number of petals, which in this variety range from ten to fourteen. These individual blossoms somewhat resemble double tuberoses. This doubling is due to both an increase in the number of segments in the corolla and to the addition of several petaloid stamens, some of which bear functional anthers. In addition to the increase in petal number this seedling usually has a greater number of open blossoms on each flower head than is found in other varieties. Figure 4, *A* shows another double Freesia beside typical blossoms of the commercial variety Purity, (Figure 4, *B*). The size relations of Figure 3, *A* and 3, *B* have been retained, thus indicating the gigantic dimensions of this double seedlings. This seedling is a true giant of the extra chromosomal type whose cytology will be reported in the near future. The enlarged blossom in Figure 4, *C* shows another type of doubling where petaloid stamens are absent. This condition is constant in this seedling although a great variation in petal number is found. One blossom on this plant had twenty-two petals and ten stamens while others vary down to an occasional six. It is questionable whether these double flowered varieties will ever become popular except among the collectors of plant novelties.

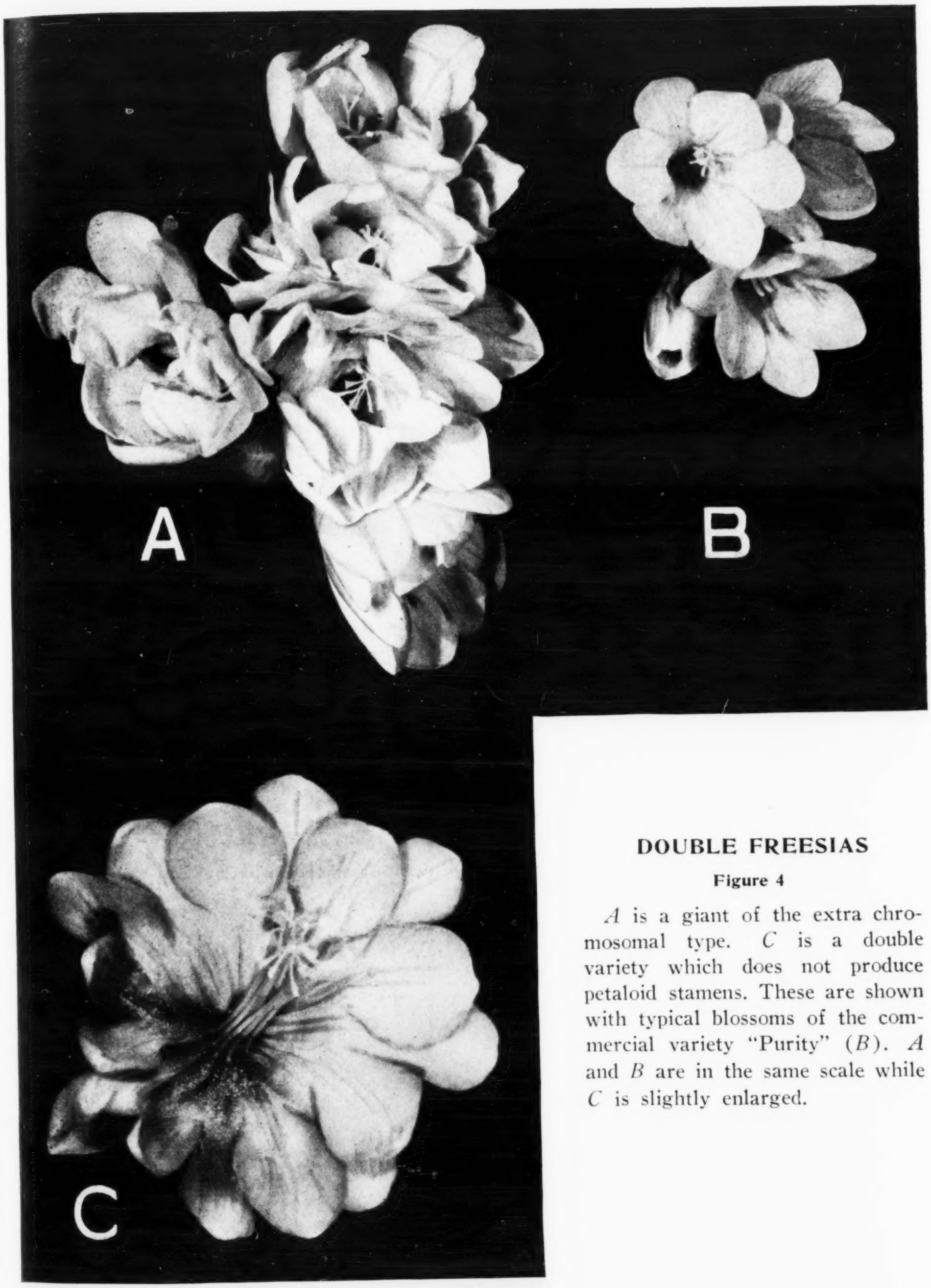
Figure 2, *H* illustrates the closed, tubular corolla similar to the original *Freesia refracta* Klatt shown in Figure

THE ORIGINAL COLORED FREESIA

Figure 3

A reproduction of part of the original illustration of *Freesia refràcta* Klatt in the Botanical Register of 1816 (Plate 135) where it was listed as *Tritania refracte*. Reproduced by permission of the Macmillan Company.

3. In contrast with this is the extremely open type in Figure 1, *C* whose narrow floral segments give an impression of an even greater diameter than really exists. The fraility of this type of blossom presents a distinct handicap in commercial competition because of the danger of injury in handling and shipping. Figure 2, *I* and *J* give extremes in size. Each of these plants was grown under similar conditions from mature corms and were photographed so as to retain their size relations. That considerable increases in size in Freesias is possible is excellently demonstrated in the larger of these two specimens, and this raises the question as to how long the hybridist should continue to make size the basis of his selections. From the commercial standpoint there is much in favor of the larger blossoms unless they are accompanied by unattractive colors. The grower finds that most of the small



DOUBLE FREESIAS

Figure 4

A is a giant of the extra chromosomal type. *C* is a double variety which does not produce petaloid stamens. These are shown with typical blossoms of the commercial variety "Purity" (*B*). *A* and *B* are in the same scale while *C* is slightly enlarged.

flowered varieties require just as much of his valuable greenhouse space as the more buxom types, while the flower buyer is willing to pay a higher price for the larger blossoms. In addition to its extremely large flower heads (the largest known to the writer), this variety is a tall-growing type with stems up to three feet in length, while Figure 2, *K* shows a drawf white variety. The individual blossoms of this last seedling are much smaller than most of the Freesias shown in this figure but its distinct beauty indicates that size alone cannot be the determining factor in making selections for commercial introduction. In Figure 1, *D* the flower is of the "bilateral" type which is often associated with varigated colors and weak stems. Although this type is usually suppressed by hybridists, the colors of some are so attractive as to offset other characteristics. The remaining types shown in these figures further portray the range of diversity found in the inflorescence of the hybrid Freesias.

The Frontispiece shows the relative size and form of a native South African species imported for study by the author and a recently introduced commercial variety known as "Elder's Giant White." This comparison is of especial interest since the species shown is undoubtedly the recently renamed *Freesia Metelerkampiae*, Bolus which according to Mrs. L. Bolus is the same as that illustrated in the "Botanical Register" and reproduced in part in Figure 3.

Crosses made with some of the above flower types are beginning to yield interesting data. Due to the time required to bring Freesia seedlings into blossom, these are too incomplete to warrant a detailed report at this time.

From the above description and accompanying figures it is evident that the hybrid Freesia has many corolla forms quite different from the inconspicuous South African species. It is remarkable that the many floral types have arisen from a single species with its small number of recognized native varieties. (Some authors list some of these varieties as separate species.) This variability offers a plastic medium for the hybridist and forecasts some of the flower types which may be found among commercial selections in the near future.

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SIZE OF FAMILY

In Stocks Supplying Students to Newcomb College

HARLEY N. GOULD and BEATRICE DAVIS
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THE reproductive rate in college family stocks has been discussed by several writers after quite extensive study but we hope that the present contribution may yet be of some value. The region from which the material is drawn is rather sharply localized, and the aim is to present the facts in such a way that they will be useful for comparison.

Material and Method

The data were collected by personal interview with 250 women students of Newcomb College, in attendance 1926 to 1928, members of all four classes being used. The subjects would probably average near twenty years of age, so that the families from which they came were being produced about 1900 to 1910.

The distribution of the subjects according to the states in which their immediate families resided at the time the information was gathered may be found in Table I. Louisiana makes by far the largest contribution to the student body at Newcomb, and over half the total college enrollment comes from the city of New Orleans. The individuals of the group studied were almost all born in the Southern United States, and mainly of native parents, although there has not been a definite restriction to "native born of native parents." No records were made of ancestry or religion. There are, however, at least 47 Jewish names among the 250 subjects, and Catholic families are certainly quite numerous in any group chosen at random from the state of Louisiana.

Growing as it has out of a problem assigned in a class, the method of collecting and classifying the material has some defects. The most obvious, perhaps, is the failure to make certain that the "cousin families" are complete. It is possible that a few of the married uncles and aunts of the students may yet have more children. It is also possible that some of the unmarried persons of the "parental generation" may subsequently have families. The general uniformity of the results, however, indicates that the facts have not been much distorted by the methods used.

From each subject the following information was elicited, sometimes after consultation of the student with her parents: number of brothers and of sisters, born alive; number of father's brothers, father's sisters, mother's brothers and mother's sisters, born alive; and the subsequent history of these uncles and aunts including their children born alive. In tabulating the history of the parents' sibs, age 21 was arbitrarily chosen as "maturity." If an uncle or aunt failed to attain that age, he or she was marked "died". If he or she reached age 21 and never subsequently married, up to the time of the questionnaire, the designation was "unmarried", even though the individual had died in the meantime. If married, the number of male and female children born was noted.

The information gathered has been put together in Table II, in the form of frequency distributions, with the number of families and the number of individuals concerned in each array, and the summarized result of each frequency distribution in the form of the *mean per family*, which seems the most convenient figure to use, although in some cases it is not very valuable. This table is the basis of the following discussion.

The Parental Generation

The parental generation includes the parents of the students and all their sibs. This is subdivided into *fathers' families* (fathers and all sibs) and *mothers' families* (mothers and all sibs). Within each of these, males and females are treated separately, and also combined.

Total family size. The average number of children born in the parental generation is 5.37. Counting back, arbitrarily, thirty years from the approximate time of origin of the student generation, we may assume that these 500 parental families were being produced about 1870-1880. Baber and Ross[1] obtained a mean of 5.44 born per family in native Middle West American families coming into being about 1857-1877, and Holmes[2] found that the parents of University of California students belonged to families averaging 5.21 persons. Thompson,[5] after an extensive inquiry embracing many different regions, gives 6.01 as the average size of family among the parents of college students for the United States generally, 6.38 for the whole South, and 6.35 for the "West South Central," which last includes 1313 families from Arkansas, Louisiana, Oklahoma and Texas.

All of these means are of course too large to represent correctly the productivity of the stocks, because, with the method of selection used, no childless families are included, and chance favors the presence of the larger families in the groups studied.

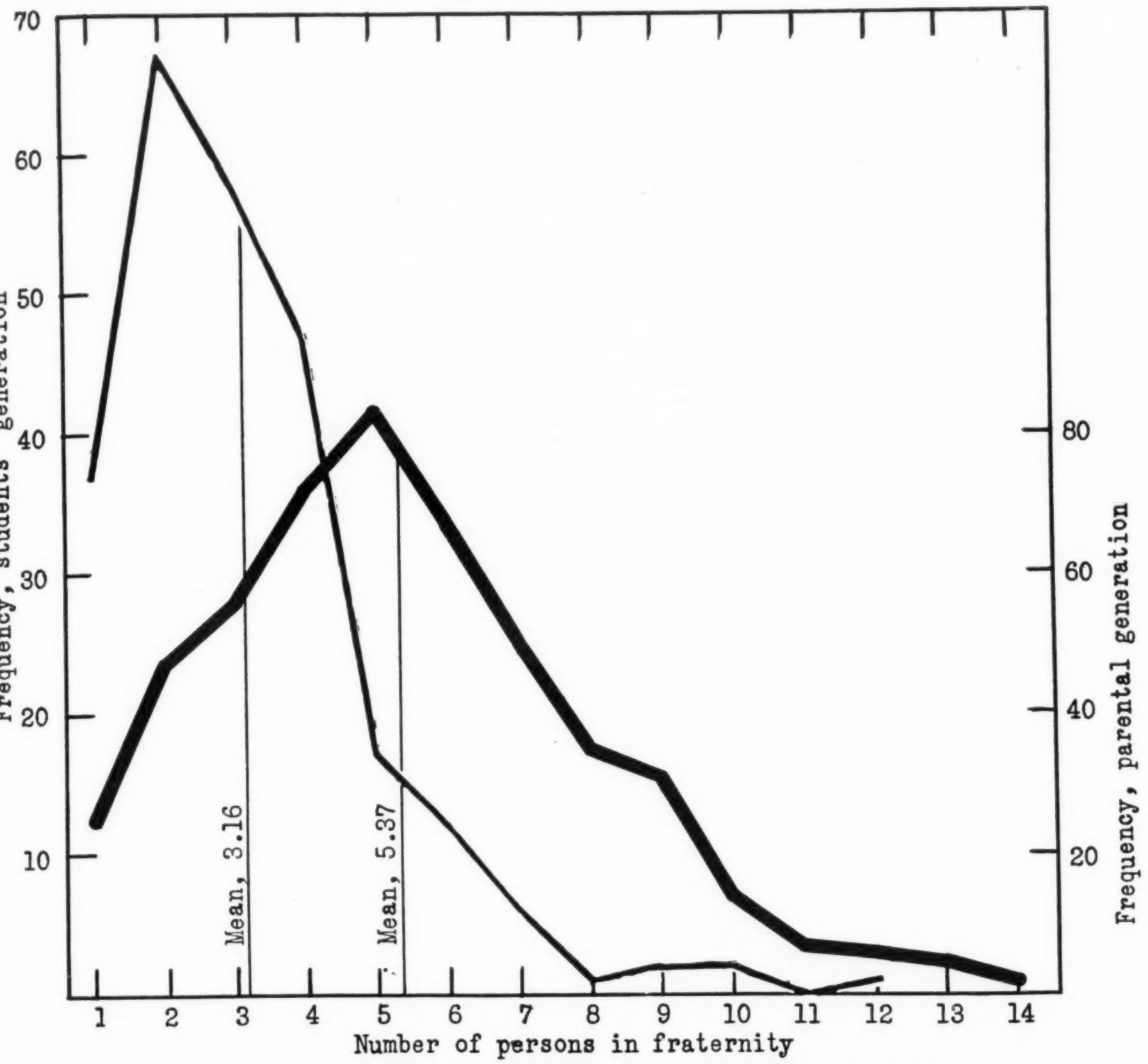
By reference to Table II it will be observed that the males born in the fathers' families greatly outnumber the females, and the reverse is true of the mothers' families. These unusual sex ratios are evidently the result of the selection of the material. Fraternities with no males cannot be included in the fathers' families, and the families with the larger numbers of males have a better chance of being hit upon than those with only one or two males. The situation is exactly opposite in the mothers' families. The sex ratio for the entire parental generation is 109.6 males to 100 females.

Death before maturity. Of the total parental generation 11.85 per cent of those born, or .64 person per family, died before maturity. The deaths among the males (13.47 per cent) exceed those among the females (10.08 per cent), chiefly because of the high mortality among the mothers' brothers (19.14 per cent). The number of persons per family who survived to adult life is 4.73.

We must recognize, without being able to correct it, that the death rate we have found is really too low to be truly representative, because no families in which all the members died could come into our material.

Marriage. In the total parental group .66 person per family reached adult life and remained unmarried. This figure does not give the true measure of the failure to marry, being influenced by selection and by the death rate before maturity. Of those who reached adult life 13.95 per cent did not marry. It seems better, however, to calculate the percentage of unmarried only from the females of the fathers' families and the males of the mothers' families, because these groups are less subject to the effect of selection. If we do so we find that 16.87 per cent of the number who reached age 21 have not married. This amounts to .80 person out of the 4.73 adults per family, and leaves 3.93 married persons.

Fertility. Of the 1,785 married persons of the parental generation, including the students' parents and their married sibs, 346, or 19.38 per cent had produced no children when our information was collected. This percentage of infertility in the stock is only approximate. In the first place, 250 of the 1,785 families are *necessarily* fertile, by the method of selection. Secondly, and offsetting this, some of the uncles and aunts, marrying late, may yet have one or two children. Using the percentage, however, as a



FAMILY SIZE OF NEWCOMB COLLEGE STOCKS

Figure 5

Frequency distribution of family size in parental generation (heavier line), based on 500 families and in students' generation (lighter line), based on 250 families.

working basis, we may reduce the 3.93 married persons in the parental generation by 19.38 per cent (.76 person), leaving still 3.17 fertile married persons per family, or the equivalent of 1.58 fertile married couples to replace one such couple of the generation before.

The Filial Generation

The filial generation includes the families from which the students come and the children of their parents' sibs.

The 250 families of which the students themselves are members average 3.16 children born, 2.08 girls and 1.08 boys. The excess of females must be partially, at least, due to the selection of students from a women's college as a starting point for the investigation. Families without girls cannot be included and if there are several girls there is a better chance of one being encountered. Yet it is not true that our sample contains many families with a high proportion of females. If one plots frequency curves of students' brothers and of students' sisters from the same points of reference, the two curves lie very close together throughout. There is an average of about one extra girl in each size-class of family.

The difference between the average family of the parental generation (5.37) and the average student family (3.16) is 2.21 persons, a drop of 41.15 per cent in one generation. This decline is greater than that found by Baber and Ross (38.42 per cent), Holmes (29.8 per cent), and Thompson (33.6 per cent, based on corrected means) in the studies cited above. If we use for particular comparison Thompson's West South Central group, which is nearest to ours regionally, we see that the falling off is only 26.3 per cent (based on corrected mean of parental generation).

The comparisons between families of students and families of their parents probably give an exaggerated idea of the decline in family size. Both generations, it is true, are selected from fruitful families. But suppose the student generation were being selected in the same way as the parental, *i. e.,* from *their* children in college. Some of the families which are included in the present work would have no fruitful members and no representation, and these would be in general the smaller families. The average family so selected would be larger than if selected from its own members.

Turning now to the 1,535 "cousin families" (children of parents' sibs), we find that the total average size of the family is 2.24 for all families, or 2.89 for the fruitful ones only. As stated previously, we have no actual check on the completeness of these families, but we are of the opinion that the number of children yet to be born of persons who have nieces in college would not greatly change the figures at which we have arrived.

The sex ratio among the children of the parents' sibs is 109.3 males to 100 females, almost exactly the same as in the total parental generation. Recalling that the ratio in the student families is 51.9 males to 100 females, we see that the excess of women is found only in the selected group.

The student families have an average of .27 person more than the fruitful families of their parents' sibs; but the student group has been subject to the possible weighting of large families while the cousin group has not. The two cannot be directly compared. We do not see any way of correcting the figure for the student family so as to avoid entirely the effect of selection. If we employ the method described by Lenz[4] and discussed by Holmes,[3] the calculated mean per student family would be 2.30.* But our selection has been of females only. If we then apply the reduction to the females only, it would bring down their average from 2.08 to 1.57 per family, which, added to the 1.08 males, would give 2.65 children. We are not sure, unfortunately, that the number of males in the student family is typical, and so can hardly place confidence in this procedure.

The 1.439 fertile families producing all the filial generation actually contain 4,223 children, or an average of 2.93 children per family; and the number of families among these on which selection has acted is only 250. The mean of 2.93 is a fairly dependable measure of the secundity of those persons in the parental generation who had any children at all.

Conclusion

During the rise of the parental generation, the stock represented by our sample was not only maintaining itself, but probably increasing. Considering the bias toward large parental families involved in selecting them at random from living adult representatives of the filial generation, it is doubtful how *much* the stock was increasing.

*Given a table of frequency of children per family, in a group selected from those children, the method to which we refer consists in dividing the number of families in each class by the number of children in that class, and dividing the sum of the quotients so obtained by the total number of families.

The deaths before maturity, failure to marry and childlessness being as they were in our sample of the parental stock, a family of about 3.5 children born would have been sufficient to maintain their numbers.

Beginning with the birth of the filial generation, we can be pretty sure the stock is on the decline. Even with a greatly reduced death rate,—the annual deaths per 1,000 in New Orleans have fallen off about 56 per cent between the childhood of the parental and that of the filial generation,—an average family of 2.93 living children cannot be expected to hold its own.

TABLE I—Distribution of Students' Families by States

Louisiana	193	Alabama	7	Florida	2
Mississippi	26	Georgia	5	Missouri	2
Texas	9	Tennessee	3	Virginia	1
		Arkansas	2		

TABLE II—Size of Family in stocks supplying students to Newcomb College

		Number per family															Number of families	Number of individuals	Mean per family
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
Fathers' families	males born		42	37	58	52	27	17	10	5	1		1					250	865	3.460
	males died	195	36	11	5	2	1											250	86	.344
	males unmarried	185	41	19	4	1												250	95	.380
	males married		65	52	63	43	14	9	2	2								250	684	2.736
	females born	34	69	62	44	21	13	5	1	1								250	519	2.076
	females died	205	37	6		1		1										250	59	.236
	females unmarried	196	39	11	2	2												250	75	.300
	females married	66	76	53	32	12	7	4										250	385	1.540
	total born		12	23	23	30	48	30	26	23	20	6	3	2	2	2		250	1384	5.536
	total died	173	39	22	7	7	1			1								250	145	.580
	total unmarried	152	52	28	13	3	1	1										250	170	.680
	total married		23	32	50	43	43	21	11	13	7	3	3	1				250	1069	4.276
Mothers' families	males born	40	72	53	35	22	11	11	3	2	1							250	538	2.152
	males died	184	39	20	5	1	1											250	103	.412
	males unmarried	196	37	12	5													250	76	.304
	males married	71	85	51	19	16	3	2	1	1	1							250	359	1.436
	females born		39	67	60	43	20	15	4	1		1						250	761	3.044
	females died	201	34	11	3		1											250	70	.280
	females unmarried	190	43	12	4		1											250	84	.336
	females married		68	78	58	25	17	4										250	607	2.428
	total born		13	24	33	42	35	37	24	12	11	8	4	4	3			250	1299	5.196
	total died	157	51	17	18	3	3		1									250	173	.692
	total unmarried	153	54	28	11	3	1											250	160	.640
	total married		29	51	42	43	34	21	17	5	3	2	2		1			250	966	3.864
Total parental generation	born		25	47	56	72	83	67	50	35	31	14	7	6	5	2		500	2683	5.366
	died	330	90	39	25	10	4		1	1								500	318	.636
	unmarried	305	106	56	24	6	2	1										500	330	.660
	married		52	83	92	86	77	42	28	18	10	5	5	1	1			500	2035	4.070
Student families, born	males	96	81	46	18	5	3		1									250	269	1.076
	females		99	81	40	16	9	4	1									250	521	2.084
	total		37	67	58	47	17	12	6	1	2	2		1				250	790	3.160
Children born of fathers' married brothers	males	188	122	68	33	13	7	2							1			434	469	1.081
	females	165	143	79	33	7	4											434	448	1.032
	total	83	105	106	59	38	16	12	9	4	1						1	434	917	2.113
Children born of fathers' married sisters	males	146	105	91	21	13	5	2	1				1					385	457	1.187
	females	170	102	62	29	16	2	3	1									385	412	1.070
	total	91	64	90	54	33	22	14	6	8	2				1			385	869	2.257
Children born of mothers' married brothers	males	149	95	68	30	10	2	3	1	1								359	404	1.125
	females	164	98	58	25	9	2	3										359	353	.983
	total	96	53	83	61	29	17	6	8	1	2		1	1	1			359	757	2.108
Children born of mothers' married sisters	males	131	97	69	34	9	10	5	2									357	467	1.308
	females	143	91	72	32	9	6	3		1								357	423	1.185
	total	76	59	78	46	37	26	9	11	8	6	1						357	890	2.493
Children born of parents' sibs, total	males	614	419	296	118	45	24	12	4	1			1		1			1535	1797	1.171
	females	645	434	271	119	41	14	9	1	1								1535	1636	1.066
	total	346	281	357	220	137	81	41	34	21	11	1	1	1	2		1	1535	3433	2.236

Appendix

1. As might be expected, there were some fruitful second marriages in this stock. For the sake of simplicity, half-sibs were counted as full sibs. Among the fathers, 12 had, altogether, 37 half-sibs, and among the mothers, 13 had a total of 24 half-sibs. One of the

students had a half-brother, and one a half-sister. In the cousin families there were only two cases where any of the members were the result of second marriages; in one case two males, and in the other one male, came from the second marriage.

2. There are 47 students' families among the 250 who are quite certainly Jewish. The mean number of children born in the parental generation of these is 5.32 and in the students' families themselves 2.62. The decline in family size has been greater among the Jewish families than elsewhere.

3. There were 5 cases where a sib of one parent married a sib of the other, involving 20 offspring who are counted twice by our method, since they appear as children both of mothers' and of fathers' sibs.

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THOMAS ANDREW KNIGHT

(1789-1838)

KNIGHT was the son of a successful industrialist. On his farm near Elton he carried on a great variety of experiments with domesticated animals and plants, leading to the production of many improved forms, and to discoveries of great scientific interest. He was the first person to report the phenomenon of dominance—curiously enough, in peas, and when Mendel was just a year old. Announcing his discovery before the Horticultural Society of London, on June 3, 1823, he stated the reasons for using the pea for his experiments as follows:

> The numerous varieties of strictly permanent habits of the pea, its annual life, and the distinct character in form, size and color of many of its varieties induced me, many years ago, to select it for the purpose of ascertaining, by a long course of experiments, the effects of introducing the pollen of one variety into the prepared blossoms of another. My chief object in these experiments, was to obtain such information as would enable me to calculate the probable effects of similar operations upon other species of plants, and I believe it would not be easy to suggest an experiment of cross-breeding upon this plant, of which I have not seen the result, through many successive generations.

He carried the crosses through a number of generations and noted that, in a cross of a strain having gray seed coats with one having white, no immediate effect took place, but that in the next generation the plants bore gray coated seeds, and that in the back-cross to what he called a "permanent white" variety two types of seed coats appeared, gray and white. He did not report on the numerical ratios of the two kinds, and thus missed the essential feature of Mendel's discovery, having apparently no inkling of segregation as Mendel conceived it, or of its mechanism. In his crosses of currant varieties he also noted the dominance of the red fruit color over the white.

He was quite successful in producing through hybridization improved varieties of apples, peaches and currants. Hybridization of existing desirable varieties with cold-resistant forms, themselves valueless horticulturally, but transmitting their desirable hardiness to some of their progeny, also was first deliberately undertaken by Knight.

THE SILVER MOUSE

A Recessive Color Variation

L. C. DUNN AND LORNA W. THIGPEN
Columbia University and Storrs Agricultural Experiment Station

IN 1927 we obtained from an English fancier* three color varieties of house mouse which apparently had not been analysed genetically, although they had been represented in the English fancy for several years. These were known as "silver grey," "silver brown," and "pink-eyed silver" respectively. The first appeared to be black mice showing a mixture of white-tipped, all-white, and black and white hairs. The silver browns were of a lighter shade than the standard chocolate, and also showed white-tipped and some all-white hairs, although they were never silvered to such an extent as the silver greys. The pink-eyed silvers resembled the usual pink-eyed black variety but were somewhat lighter in color and this coupled with the name applied to them suggested that they might be the pink-eyed form of silver grey.

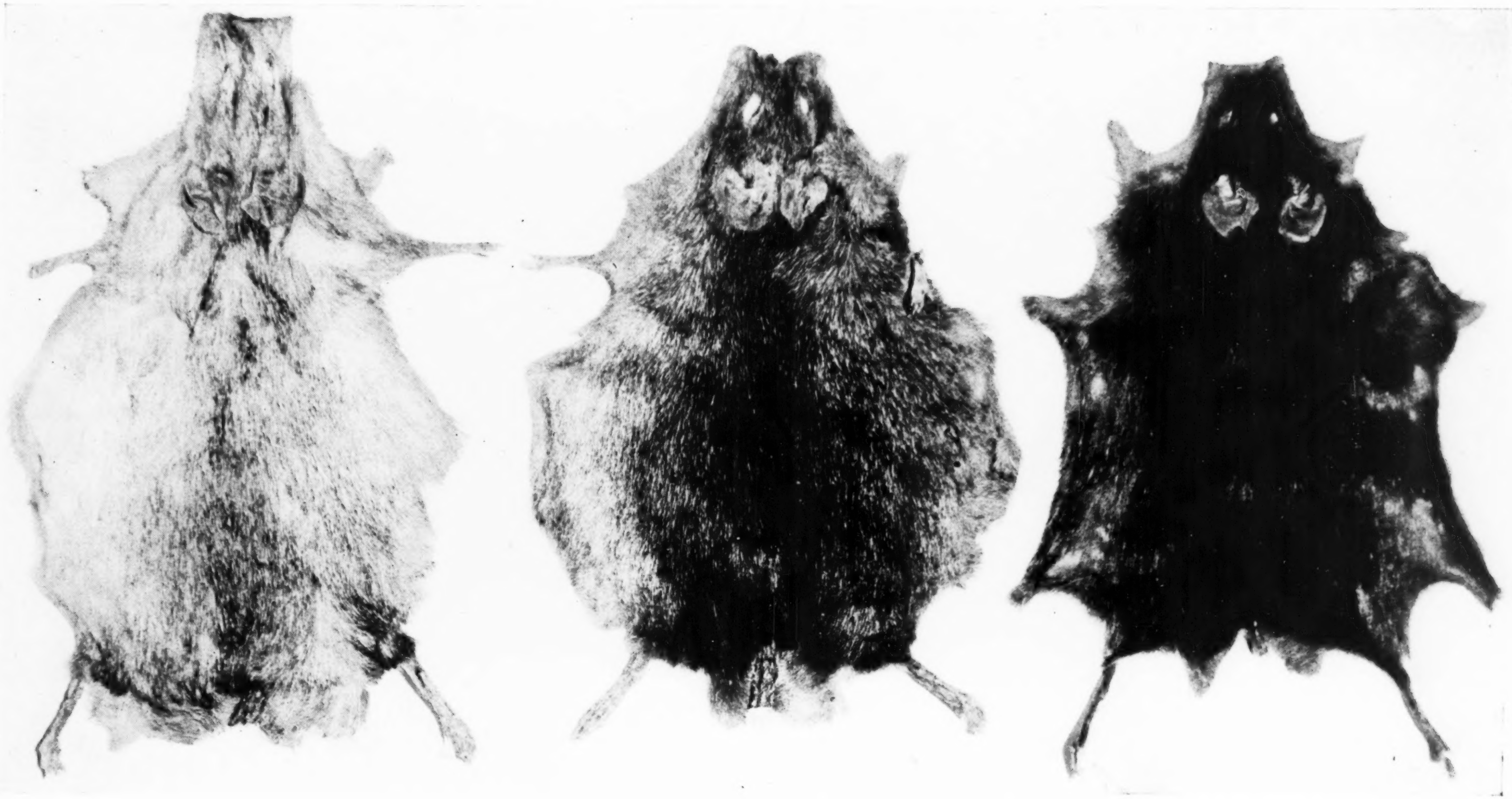
The silvering as seen in the greys and browns recalls a variation which Hagedoorn[2] reported as having arisen by mutation in his mouse colony. Hagedoorn's silver seemed, from rather meagre evidence, to be inherited as a recessive and to be independent of agouti and dilution. Its relationship to the silver of the English fancy is discussed later. A similar though more intense silvering occurs in some varieties of rabbits, notably in the "silver champagne." In addition to these types, white and white-tipped hairs are occasionally found in dark varieties of mice and other rodents, sometimes as age or moulting effects, sometimes in irregular patterns, but in our experience never as a true breeding varietal characteristic.

Description of the Silver Varieties

Purebred silver greys of the strain studied are quite variable in the degree of silvering. This variability is recognized in the English "Standard" by the adoption of classes for dark, medium, and light silver greys. (Figure 6.) The young mice in their first pelage are frequently black, although usually a few silvered hairs can be seen on the head, behind the ears, and on the flanks. Some are well silvered in their first pelage and these usually develop into light silvers. All appear to become progressively lighter (more silvered) with age, the males showing in general more silvering than the females. Eventually all offspring of silvers develop the silver coloration.

A gross examination of silver greys shows that this coloration extends to all parts of the pelage, although the belly is lighter than the back. The fur contains hairs of several sorts: (1) all white; (2) all black (these probably only in dark silvers); (3) black hairs with white tips; (4) hairs with several white and grey or black bands. Microscopic examination of glycerin preparations of these hairs shows that some have no pigment at all (type 1); in others the pigment granules are reduced in number and scattered (types 2 and 3) while in others white areas alternate with sparsely pigmented ones. Silvering is thus the result of a reduc-

*Mr. William Turton, Ilkeston, Notts. Grateful acknowledgment is made to Mr. G. N. Pickard and Mr. Stuart Russell for help in obtaining these and other strains of mice and to Dr. F. A. E. Crew and the Animal Breeding Research Department, University of Edinburgh, for their courtesy and hospitality.



VARIATION IN EXTENT OF SILVERING

Figure 6

Skins of light, medium and dark silver gray mice, showing variation in the expression of the character. Purebred silver grays are frequently black when young, becoming increasingly silvered with advancing age. The silver pelage is produced by a single gene, recessive to black.

tion in the number of pigment granules and of their entire absence from certain areas and from entire hairs. Variations in the intensity of silver are due to variations in both of these peculiarities: that is, light silvers have more white hairs and larger unpigmented areas on the colored hairs.

Hairs from silver browns show the same types as above, except that the proportions of white hairs and of white in colored hairs are generally much less than in silver greys. The hairs of pink-eyed silvers have not been studied.

Inheritance of Silver Grey Coloration

Silver greys from our strain (descended from a single pair obtained from Mr. Turton), were first crossed reciprocally with black self-colored mice. The F_1 mice (10) were all black and showed no silvering throughout life.* Seven F_1 black females bred to an F_1 black male produced 51 black and 18 silver greys, an obvious 3:1 ratio. An F_1 black male backcrossed to silver grey females gave 43 blacks and 43 silver greys, indicating that silver-greys differ from blacks by a single recessive gene for silvering. Segregation of black and silver grey was in some cases clear in the first pelage. In other litters the distinction was not clear until later and segregating litters were therefore classified when two months old. No changes from black to silver occurred after this age.

Silver greys were then crossed with silver browns. This cross produced only silver greys (14) showing that the same silver gene was present in the silver browns. A cross of silver brown by black gave black in F_1; these backcrossed to silver brown gave 11 blacks, 11 silver greys, 8 silver browns, and 6 chocolates. Obviously, silver brown differs from chocolate by the same gene which differentiates silver grey from black. It was noticed that the F_1 animals from the cross of silver grey by silver brown were much lighter silver than we had ever seen in either parent stock. Such very light silver greys appeared also in later generations from the cross of silver by black, and also from crosses of silver grey by self brown mice so that the brown gene although ordinarily recessive to black seems to act as a modifier of silver in blacks heterozygous for brown.

Pink-eyed Silver

A few experiments showed that the third color variety, pink-eyed silver, does not contain the silver gene. A pink-eyed silver female crossed with a silver grey male produced in F_1 only black mice, and a small F_2 consisted of blacks, *blues* (dilute blacks), silver greys, silver blue, and pink-eyed mice like the pink-eyed grandparent. The same pink-eyed silver female was then crossed with a dilute black male and gave only dilute black young, showing that the paleness of this pink-eyed silver type was due not to the silver gene but to the familiar dilution gene (*dd*). Silver as applied to this variety and to other dilute types e. g., silver fawn- (Durham, '08), has apparently been used by the English fancy in a sense quite different from its application to silver grey, for in the latter it refers to the whitening of the individual hairs and in the former it refers to the ground color of all the hairs, which according to the English Standard should in pink-eyed silvers be "of a delicate shade as near as possible to that of a silver coin." In order to avoid confusion in nomenclature it will be best to reserve the term silver for the variation described in this paper and to follow the practice of indicating varieties by their genetic composition rather than by their descriptions e. g. silver black (the fanciers' silver grey), silver brown, dilute silver black, etc.

*We have since noticed that occasionally black mice heterozygous for silver may show silvering on the belly i. e. dominance is not always complete.

Purebred silver grays are free- variation in the expression of the character. Pu- medium and dark silver gray mice, showing varia- by a single gene, recessive to n young, becoming increasingly silvered with advanc- quently black when y- black.

Other Combinations of Silver

In order to test the effects of the silver gene on other colors and especially on yellow a few crosses of silver grey by black agouti (wild type) were made. The F_1 mice were black agouti, some of them darker than wild type. Such F_1s backcrossed to silver grey produced 41 black agoutis, 22 blacks, 33 silver greys, and 27 of a new type representing the combination silver agouti. The silver agoutis, like the silver greys, were variable in appearance, some being well silvered, others being very similar to black agouti, except for white or light bases in the hairs which serves as a distinguishing mark of silver agouti. The yellow band on the agouti hairs was not visibly affected by silver. As these mice grew older many became less silvered and almost indistinguishable from black agouti, a condition just the reverse of the tendency of silver grey to lighten with age.

The backcross ratio from this experiment shows an excess of the original combinations (silver non-agouti and non-silver agouti) which total 74 while the new combinations total only 48. This can only be taken to indicate that there is no *close* linkage between silver and agouti, but the numbers are too small to decide whether these genes are loosely linked or independent.

One cross of silver grey by yellow (English Red) gave in F_1 yellows (some of them sooty and sable) and blacks. F_1 yellows backcrossed to silver grey gave 7 yellows (including sooties and sables), 7 silver greys, 8 blacks, and 9 of a new type *silver yellow*. The silver yellow, silver agouti, and silver sable varieties have now been inbred for several generations and show the same variations in intensity of silvering as the silver blacks. As in the case of the agoutis the chief effect of silver on yellow is at the base of the fur which becomes very light, although white tips and silvered shafts were also to be seen on the yellow ground. As in silver agouti, the silvering decreases markedly with age.

Comparison with Other Cases of Silvering

Hagedoorn has already recorded a recessive silvering in house mice. The silvering first appeared at the moult (at about nine weeks according to Hagedoorn) and consisted of white hairs interspersed with dark ones in black, brown, blue, and agouti animals. They looked almost exactly like medium silver rabbits. From this brief description and the gentic behavior of Hagedoorn's silver, which segregated as a recessive, it seems likely that it was the same variation as that reported in this paper, although its apparent disappearance prevents a breeding test.

The silver mouse closely resembles the silver rabbit (Argenté de champagne) and may represent an analogous variation although in the rabbit silvering shows no simple segregation in crosses and appears to act as a dominant. Possibly other modifying genes in addition to a main gene for silvering are concerned[1, 3]. In mice also other genes probably influence the grades of silvering in the light and dark types. In both species, the silvering becomes lighter with age although this similiarity is shared by other variations which are genetically distinct such as greying of the hair in man and other animals, and the roan variations in man and other animals.

This variation adds another useful color gene to the many already known in mice. Since its effects vary with age and are modified by other genes (e. g. brown) it may provide valuable material for studying the causes of pigment production and diminution.

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CONGENITAL EAR AND SKULL DEFECTS IN SWINE*

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Idaho Experiment Station

A PIG OF THE STRAIN HAVING DEFECTIVE EARS

Figure 7

In this instance only the left ear is defective. All the defective-eared individuals so far observed trace back to the same individual, having this defect. Thus its heritable nature is quite certain, though the mode of inheritance has not been determined.

IN a previous paper[1] the author has discussed congenital ear defects, in a Berkshire pig, that were somewhat similar to the ear defects described in this paper. No other information seems to be available on similar specimens within that breed. Some very marked skull defects were found on the same side as the defective external ear in this specimen and it was

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SKULL AND EAR DEFECTS ASSOCIATED

Figure 8

This individual showed marked skull defects associated with the defects of the external ear, when the skull was examined five days after birth. Whether the skull defects are regularly associated with the ear defects has not been determined.

concluded that there may be some common origin for the ear and skull defects.

Studies have been in progress at this Station for some time with a view of making a genetical analysis of ear and skull defects as they have been identified with a strain of Duroc Jerseys which traces to a noteworthy show boar whose dam had this defect. This defect, as it affects the external ear, has been found in herds in a number of states, and advice has recently been issued by the editor[2] of one of the Duroc Jersey breed papers urging the elimination of animals that produce pigs "with a shriveled ear or no ear at all." And, further "we find some pigs with small deformed ears now, even when it is ten generations away from the source."

External Ear Defects

The defects in the external ear may vary from a slight modification of the anterior border of the ear to a very pronounced reduction in size. One of the boars used in the breeding work (Figure 7) has a left ear about one-fourth the size of the right ear. The ear is also somewhat shriveled and jagged in outline toward the attachment in front. Where the ear opening would be under normal conditions there is a slight indentation of the skin, pointing in the direction of the base of the skull, only one-sixteenth of an inch deep. The indentation resembles a small pit in the skin.

In some specimens (Figure 8) the ear may be very smooth, thick, short and also about one-fourth normal size. The end of the ear may also be blunt and decidedly lacking the pointed appearance which characterizes the ears of swine. In most of the cases observed the defective ear is turned downward and forward and is, as a rule, flush with the side of the head. In this specimen (Figure 8) a small accessory cartilagenous projection is located immediately in front of the most dorsal attachment of the ear. There are very few cutaneous ridges on the concave surface, and the edges are smooth as contrasted to more or less jagged edges in many specimens. The eminentia concha is very small and lacks the fullness which prevails in normal specimens. There is no opening into the skull, a characteristic which seems to be very commonly associated with the external ear defect.

Skull Defects

While the external ear defects have been observed for some time apparently no study has been made of the possibility of any skull defects being associated with them. A detailed study has been made by the author of three specimens with defective external ears, all of which have had a large number of defective bones in the skull. One of these (Figure 8) will be briefly discussed to show how generally the side which carries the defective ear is affected. The meatus acusticus externus is absent and there is no trace of any formation which gives the slightest indication of it. The squamous temporal which normally makes contact with the zygomatic process of the temporal bone does not do so in this case, and as a result of this incomplete development the zygomatic process of the temporal bone has a bony articulation with the zygomatic process of the malar bone only. The temporal crest is virtually absent and does not curve normally outward to blend with the external auditory canal. The zygomatic process of the temporal bone is somewhat short but broader than normal development.

The mastoid process is not large enough to form a crest on its anterior part, nor does it overlap the base of the paramastoid process. The paramastoid process is one-half normal length and very small in cross-section. The bulla ossea is only one-sixth normal size and does not have the usual fulness. Lack of complete development characterizes the occipital condyle which apparently is too dorsal in its location; it having, no doubt, been affected by the same force which has distorted the foramen magnum. The lateral occipital is also too small. There seems to be a general tendency for lack of development in the bones in the area of the meatus acusticus externus of sufficient magnitude to cause the right side of the skull to be one-half centimeter shallower than the left and also somewhat shorter. The median line of the parietal, frontal and nasal bones inclines to the defective side.

In the mandible the coronoid process and sigmoid notch are too small and the condyle is 3 mm. too narrow. The vertical part of the ramus is 4 mm. too short and the right mandible is 5 mm. shorter than the normal left mandible.

It is probable that sufficient data are available to establish association of the skull defects that have been found in the three specimens mentioned with the external ear defects on the same side of the head. The type of inheritance and more complete data on the defects will be left for a later paper.

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Anthropology and Religion

BIBLICAL ANTHROPOLOGY, *by* H. J. D. Astley. Pp. 262. Price, $4.50. Oxford University Press. 1929.

THE author, a church of England clergyman, writes from a modernistic and purely evolutionary standpoint elaborating an axiom of anthropology that "man has everywhere and in every race progressed through barbarism to civilization," and also its corollary "under a similar environment and at a corresponding stage of culture man is always and everywhere the same." Thus it is proved from their own writings that in prehistoric times the ancestors of Israel had passed through the same stages—from savagery through barbarism to the measure of civilization attained in the time of the writers of the Old Testament. Among other points of interest to the reader is the tracing of the sacraments of the Christian religion to ideas lying at the root of the psychology of the people among

whom Christianity first spread, and still further back to the evolution of culture from the common heritage of mankind in the first primitive outlook on the world. After clearly demonstrating that primitive religion is animisic, i. e., the belief that all objects are endowed with indwelling souls, he is at pains to show that the whole body of ideas concerning the earth, nature, man, the soul and the world of spirits are traceable to these early sources. They live on at the present time engaged in a ceaseless struggle with scientific conceptions of the universe.

Following this discussion of our religious inheritance our author is at pains to offer constructive criticism as to the teaching office of the church. Students of Heredity and Eugenics will share his disapproval of clergy, "who year after year preach their old bundles of sermons in a world continually seething with new problems and in which the old truths need to be put in a fresh setting," for no statements that cannot pass the bar of reason should be allowed to influence the critical student of historical probabilities. He is also at pains to show that in the light of prehistoric archaeology and our knowledge of the antiquity of man that nothing in the first eleven chapters of Genesis can be taken as literal history. We also approve his contension that the welfare of the church depends upon a strong intellectual position, for unless reason is convinced, it is not possible for the emotional appeal to be permanently effective. Thus while people tend to reason instinctively rather than formally, they are nevertheless profoundly, if unconsciously influenced by the spirit of the age, and a message not corresponding to their mental wants will pass unheeded—especially in an age when science looms so largely on the mental horizon of mankind. The advantage of new methods of teaching, coupled with intellectual alertness and courage can give the church a better hold on the life of the country, and from our standpoint, function better in a social sense. Finally, great care should be taken to recognize in teaching the principles of progressive revelation. This is at the root of all teaching of the Bible (all learning for that matter!), and is fully substantiated by the writers of the so-called epistle to the Hebrews. In short, our author points out that it is the duty of the church to interpret our religious inheritance in the light of modern scientific knowledge.

N. M. Grier.

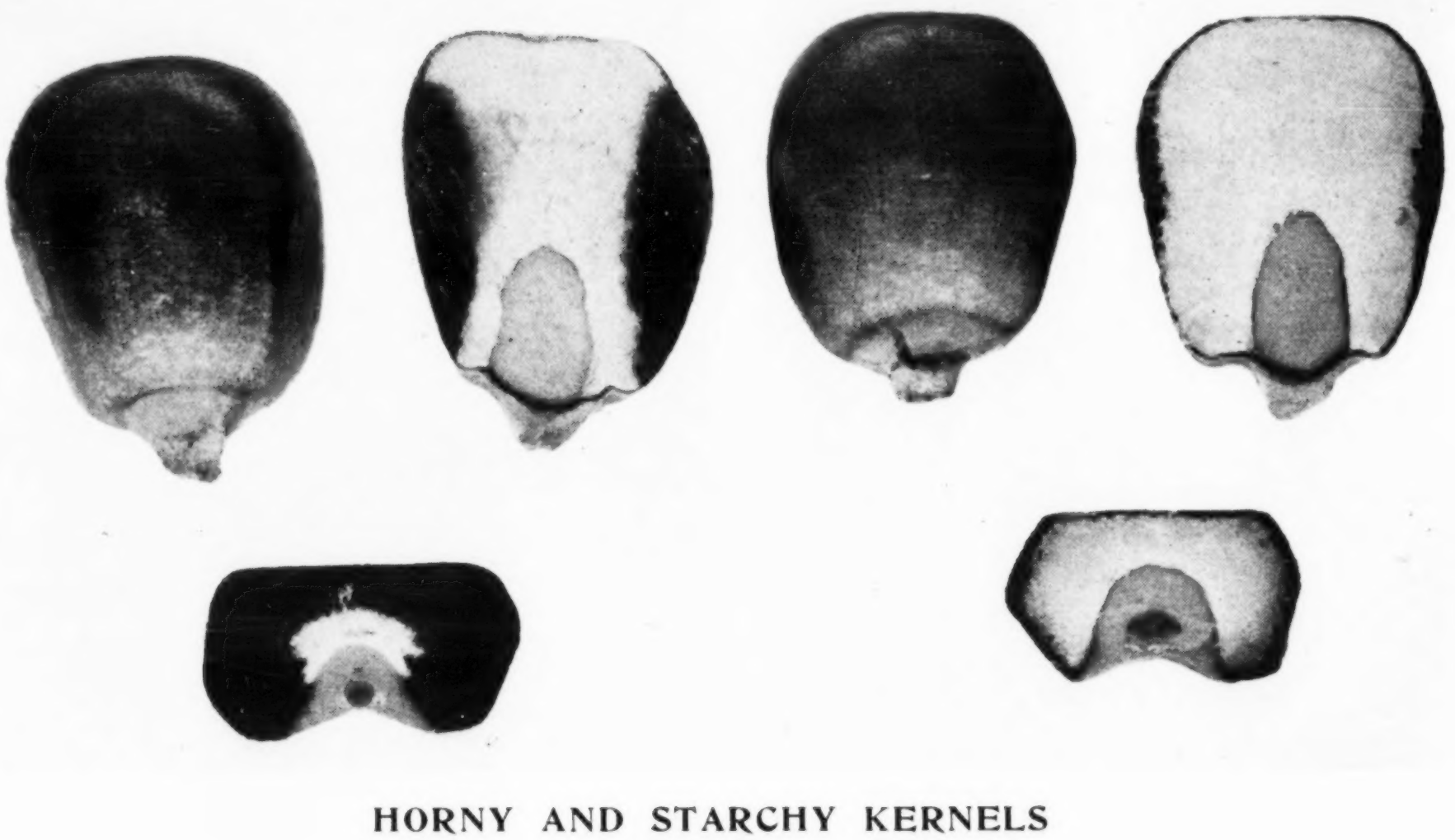
WANTED—August, 1930, Numbers of the Journal

50c a copy will be paid for August, 1930, numbers of the Journal of Heredity. Members who do not bind their Journals will confer a favor by returning their copies of this number to the office of the Association, Victor Building, Washington.

Heritable Characters in Maize

XXXVI—A Factor for Soft Starch in Dent Corn*

W. J. Mumm† and C. M. Woodworth
University of Illinois



HORNY AND STARCHY KERNELS

Figure 9

The kernels at the left are normal horny (*H*), those at the right are starchy (*h*), both types came from the same ear which was segregating for the character.

EARLY in 1927 work was begun on a problem dealing with disease resistance in dent corn. One phase of this problem was a study of the resistance of kernels of different endosperm composition to scutellum rot, a disease involving the endosperm. Many ears were found on which the kernels differed widely in their content of horny and soft starch; these ears were tested on the germinator and later seeds from each were planted in the field and the plants were selfed to determine whether the differences in composition were genetic or environmental.

Among the starchy types was a starchy ear selected from a line that had been continuously selfed for nine years and which had been uniformly horny in endosperm composition. The starchy kernels in this ear were characterized by a soft starch endosperm surrounded by a thin, corneous layer of harder starch next to the pericarp. They presented an opaque appearance to the eye as contrasted with the more or less translucent appearance of the true horny type. The starchy type was selfed and bred true for the character. In all other ways the progeny could not be distinguished from

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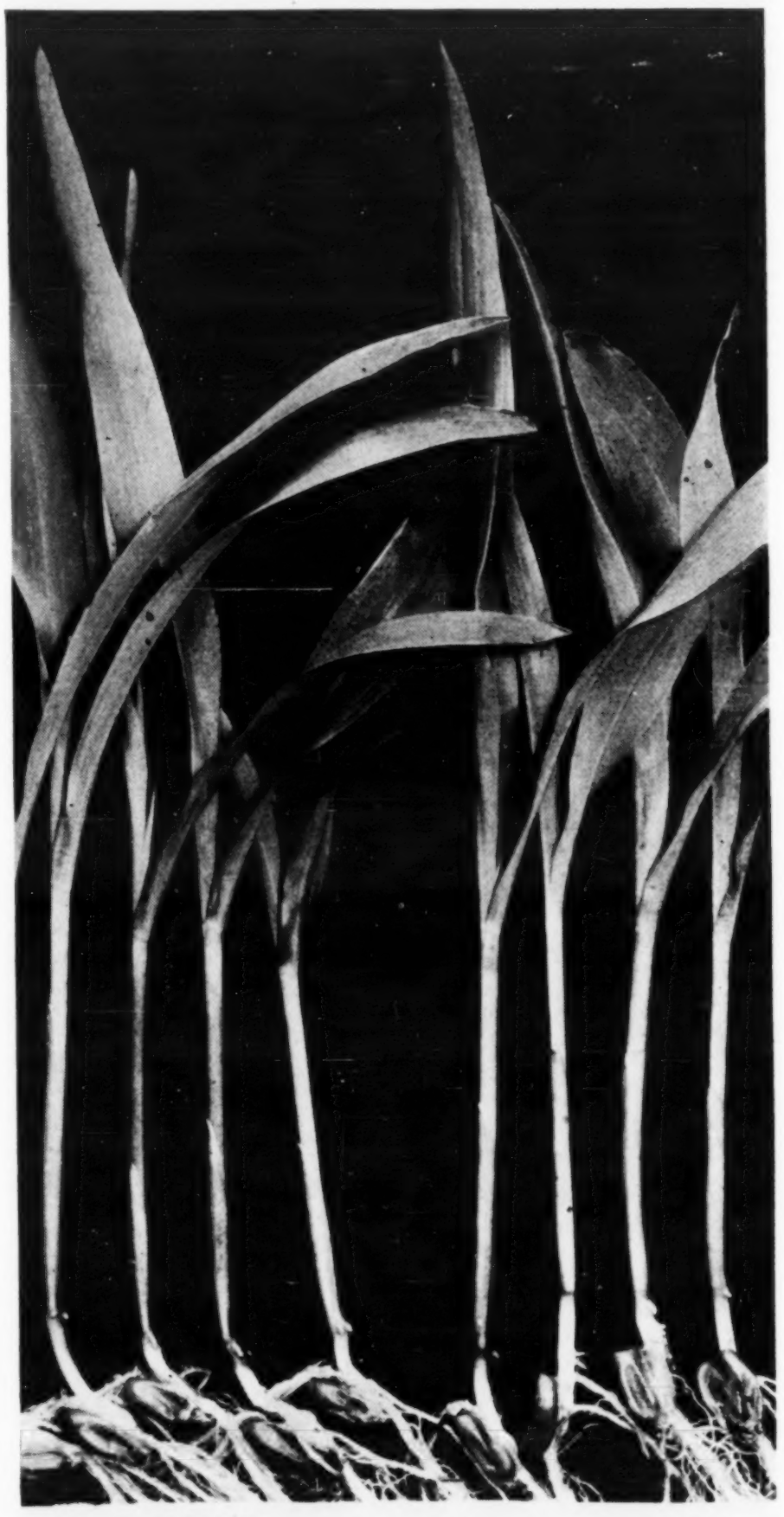
*Contribution from the Division of Plant Breeding, Department of Agronomy, University of Illinois, Urbana, Illinois. Published with the approval of the Director of the Station.

†Instructor and Professor in Plant Breeding, respectively.

the horny line from which they had originated. For instance, the original horny line was a very weak rooted type which began to lodge at or before tasseling time. The stalks curved upward before harvest time, with the lower nodes resting on the ground. This characteristic was just as marked in the progeny from the starchy ear as it was in the original strain.

From the standpoint of the problem of susceptibility to scutellum rot, it was very desirable to have segregation of starchy and horny kernels on the same ear, for in that case both would be developed under the same environmental conditions, and any differences in reaction to inoculation might be attributed to genetic differences. Crosses between the starchy type and the original horny type were made during the first year. The horny condition proved to be completely dominant in the cross, regardless of which type was used as the female parent. In the following season, the F_1 generation was grown and a number of backcrosses made with the recessive starchy type. The crossed ears segregated in a 1:1 ratio when either the hybrid F_1 or the starchy type was used as the female parent. When the F_1 plants were selfed, they segregated in a 3:1 ratio of horny to starchy (Table I).

When the character was first noted, it was supposed that, through faulty technique, an ear had at some time been contaminated during selfing with stray pollen from flour corn (*Zea mays amylacea*). There is enough evidence at hand now to show that this was not the case. In the first place, when the starchy parent is crossed with the horny type, the progeny are entirely horny. When a floury plant is pollinated with pollen from a horny plant, the progeny are floury. In the second place, when the F_1 of the horny $\times$ starchy type is selfed, the segregating ratio is 3 horny: 1 starchy. When the F_1 of the horny $\times$ floury type is selfed, the ratio is 1 horny: 1 floury, according to Hayes and East,* though the types are sometimes difficult to distinguish. Various combinations between the starchy and floury types indicate that the two characters are dis-



STARCHY SEEDLINGS AS VIGOROUS AS HORNY

Figure 10

Seedlings of starchy and horny type ten days after planting, grown from seeds taken from a single segregating ear.

*Hayes, H. K. and East, E. M. Further experiments on inheritance in maize. Conn. Agr. Exp. Sta. Bul. 188. 1915.

tinct from each other (Table II).

The starchy character, which is probably the result of a mutation, has tentatively been designated by the symbol *h* and its dominant horny allelomorph by *H*. It is not a defective type in any sense. The seed is as large and as viable as that of the dominant type on the same ear, the seedlings are as vigorous and the mature plants are as productive. In the tests made up to this time, the starchy type has been as resistant to scutellum rot as the horny type. Analyses for protein content show that the horny type is consistently higher in protein, though the odds are not statistically significant; analyses for oil content show that the starchy type contains the more oil, with odds of over 300: 1 that the difference is significant (Table III). Studies are now in progress to determine genetic relations of the starchy gene with other genes determining endosperm type, as well as linkage relations with other genes whose loci have already been established on the chromosomes.

Table I. Ratios Obtained in Crosses Between Horny and Starchy Types

	Horny	Starchy	Total	D	D/PE
Backcrosses					
10 X (11 X 10)	57	50	107	3.5	1.00
10 X (11 X 10)	188	182	370	3.0	.46
10 X (11 X 10)	142	138	280	2.0	.35
10 X (11 X 10)	110	122	232	6.0	1.17
10 X (11 X 10)	177	166	343	5.5	.88
(11 X 10) X 10	184	190	374	3.0	.46
413 X K-10	348	332	680	8.0	.91
414 X K-10	397	363	760	17.0	1.83
Subtotal	1 603	1 543	3 146	30.0	1.59
F_2					
413 ♂	468	136	604	15.0	2.09
413 ♀	555	160	715	18.8	2.41
413 ♂	557	179	736	5.0	.63
413 ♂	429	145	574	2.0	.29
413 ♂	558	193	751	5.3	.66
Subtotal	2 567	813	3 380	32.0	1.88

Table II. Results of Crosses Between Horny and Starchy Types. Also Between Starchy and Floury Types

	No. of ears	Horny	Starchy
No. 11 (horny parent)	18	18	0
No. 10 (starchy parent)	21	0	21
Cross 10 X 11	5	5	0
Cross 11 X 10	5	5	0
Backcross 11 X (11 X 10)	2	2	0
Backcross 10 X (11 X 10)	10	All seg. 1 horny: 1 starchy.	
F_1 (floury X horny) X F_1 (starchy X horny)	7	7	0
F_1 (starchy X horny) X F_1 (floury X horny)	9	9	0
F_1 (starchy X horny) X homozygous floury	2	2	0

Table III. Comparison of Protein and Oil Content of the Starchy Type With the Normal Horny Type

Ear No.	Type	Perct. oil	Difference perct. oil	Perct. protein	Difference perct. protein
413-1	Starchy	6.11	.50	8.9	
	Horny	5.61		9.7	.8
413-2	Starchy	5.63	.65	8.3	
	Horny	4.98		8.6	.3
414-1	Starchy	5.05	.56	7.6	
	Horny	4.49		7.7	.1
Ave. difference			.57		.4
Odds			322:1		9.16:1

Why We Behave Like Ourselves

ELLIS, R. S. The Psychology of Individual Differences. Pp. XXIII+533. $3.50. D. Appleton & Co., New York. 1928.

THIS volume is the outgrowth of the author's experience in giving courses on the psychology of individual differences to students in liberal arts and in education at the Colorado College, where he is Professor of Psychology. Its chief aim is to serve as a text for the elementary student, wherein he may gain a general knowledge of the problems, the methods and the results in this field of psychology, from the standpoint of biological experiment and statistical developments.

Psychopathological aspects of the problem and individual differences in

acquired traits have been allotted a comparatively small space, but the differences in native traits have been comprehensively reviewed. The first two chapters of the book are concerned with the problems of individual psychology, and the relationship between physical and mental traits with particular attention to scientific methodology, elemental neurology, and the hormone characteristics of various ductless glands. Chapters *III, IV* and *V* are devoted to the analysis of the individual into various traits, capacities and elemental units, by means of chemical and physical evaluations, and by direct measurement of mental response. "The ordinary individual may regard the mind as something of a unit, but on scientific investigation it breaks up into a number of smaller units. At the present time the most satisfactory analysis of these mental units would seem to be in terms of specific sensory capacities, specific imagery capacities, specific affective capacities, specific muscular and glandular capacities, capacities for connecting in specific ways these sensory, affective, and motor capacities into larger units, and tendencies to connect specific stimuli with specific responses."

About sixty pages are given to a description of the mechanisms of heredity and variation. Comments and discussions are made on early beliefs on heredity, on the inheritance of acquired characteristics; the controversy on Galton's laws, and Mendelism has been considered in some detail. In these sections the importance of heredity in determining differences in mental traits has been emphasized, but practically no attempt has been made to differentiate between hereditary traits and those acquired by means of identification (unconscious imitation) of other individuals in the environment, a possibility which is unfortunately rarely taken into account in statistical studies on inheritance of "normal" mental traits, and even less considered in the investigations of geniuses and the insane.

In the section on the effect of environment on individual differences there is a discussion of the prevalent diverse views on the relative importance of environment as compared to hereditary factors in influencing mental development. The author takes an intermediate position in this matter, but shows a strong inclination to place the emphasis in favor of the hereditarian viewpoint. Differences in mental development and traits due to age, sex and race have been presented at length with the experimental evidence extant in support of the modern views.

Nearly one hundred pages have been devoted to abnormal psychology or extreme deviations in mental traits including such topics as superiority, genius, mental deficiency, fanaticism, insanity and criminality, which lend themselves readily to comparative studies. The subject matter is elemental, but is perhaps sufficient for the general orientation of beginners in psychology.

The mind is so organized that it is possible to point out certain correlations of traits that make for individual and social differences of importance and Dr. Ellis shows how these facts may be applied to advantage in education, business, law and government. The book as a whole briefly presents a great many psychobiological facts assembled from a variety of sources; offers several viewpoints of body-mind relationships and attempts to show the possible applications of this knowledge. The text is amplified by ten tables and illustrated by forty-six line drawings. Each of the twenty-one chapters has an appended bibliography of "Suggested reading." It is an interesting review of the reasons why no two persons are exactly alike in their physical and mental processes.

N. D. C. Lewis.

HEREDITY AND INVENTION

JOSEPH ROSSMAN

*Patent Examiner, U. S. Patent Office**

THE influence of environment and heredity on human achievement is a problem which has aroused considerable discussion and research, but no conclusive evidence has yet been found which definitely points to heredity or environment as the deciding factor. The position taken by many scientists today is that heredity and environment are complementary factors, each one being different phases of the same problem depending on the viewpoint. We no longer set heredity above environment but regard each in terms of the other. There is no question that heredity and environment interact to produce the characteristics of all individuals. Both carry with them certain limitations beyond which the individual cannot go. The biologists tend to regard heredity as a limiting factor to the education obtainable by training. However, nature and nurture are really mutually inclusive. The environmental factors react on the hereditary tendencies and produce their effects by mutual interaction.

The question whether inventiveness is inherited reduces itself to the problem of the inheritance of mental capacities, tendencies and abilities. No one will deny that organic structures are inherited but is such a specific ability as inventing inheritable? All persons unquestionably inherit certain capacities and tendencies such as the sensory capacites, the instincts or unlearned responses and reflexes.

Heredity and Genius

Many workers in heredity have attempted to show that many special abilities, such as mechanical ability, artistic ability, judicial and military ability are inherited. The outstanding study was made by Galton[10] embracing a group of 977 eminent men and their relatives. This group of eminent men had 739 relatives of eminence including 50 grandfathers, 94 fathers, 54 uncles, 123 brothers, 66 nephews, 145 sons and 42 grandsons. Other studies have been made by Woods[13] on 671 members of royalty; Havelock Ellis[8] studied 1,030 British men and women of genius; Cattell[3] and Brimhall[2] made a study of American men of science. Studies have also been made by Clarke,[4] and de Candolle[5] showing that eminence runs in the same families.

It is also possible to determine the ancestry of eminent persons by a study of the social class from which they come. Galton has shown that the great majority of English scientists came from professional classes as follows:

Nobility and gentlemen	9
Military and government	18
Professional	34
Commerce	43
Farmers	2
Total	107 (11 duplicates)

Ellis found the ancestry of the eminent men and women was as follows:

	Per cent
Professions	35.2
Upper classes, officials, Army and Navy	27.8
Commercial	18.8
Crafts, artisans, unskilled	11.7
Yeomen and farmers	6.0

The study of American men of science by Cattell showed their fathers to be of the following classes:

*This article on the inheritance of inventive ability is a chapter of Dr. Rossman's forthcoming book, *The Psychology of the Inventor*. —EDITOR.

Professional	43.1	(3.0 per cent in general population)
Commercial	35.7	(34.1 per cent in general population)
Agriculture	21.2	(41.1 per cent in general population)

These findings do not necessarily mean that heredity is the sole cause of eminence. Children born in eminent families inherit not only their organic mechanism from their parents but also their social environment. The Bach children, for example, were born in a musical environment and were under the constant stimulation of music. This might have been decidedly more important than their organic hereditary.

Bogardus analyzes the fundamental conditions essential to genius and achievement as follows:

1. Social environment which is mentally stimulating. Genius rarely matures under a widespread pall of mental stagnation. There must be mental contacts which strike fire and some general appreciation of achievements that a genius can effect.

2. Thorough training. There are only a few successful persons today who have not spent time and energy in developing and perfecting techniques. It is becoming increasingly true that special ability must have a commensurate scholastic and practical training as a basis for complete self-expression. It is fair to assume that the greater the potential ability the greater will be the value of both extensive and intensive training. Nearly all accredited geniuses, whether of the Paderewski or the Edison type, report that many hours daily are spent in "practice" and hence in training. In order that all the special abilities of a person may be fully developed, his education must begin early, proceed as systematically as possible, and be continued throughout life. The greater the genius the more imperative is a thorough training.

3. Freedom from the struggle for bread. If energy is continually expended in securing the necessities of life, genius is to that extent hampered. Sufficient means for travel and research is another essential.

4. Social respect as a medium for the development of self respect. Persons with special talent are often a thermometer of the social reflections of themselves. A genius is handicapped if he grows up as a member of a race that is despised by a dominant race, in a community where luxury spreads an enervating virus, or where vice in any form destroys the energies of life.[1]

Source of Material

In order to throw some light on the heredity of invention, first-hand information was obtained from a group of over seven hundred inventors consisting of the most active and important inventors of this country, such as Dr. Elihu Thomson, Dr. Reginald Fessenden, John Hays Hammond, Jr., Dr. Miller Reese Hutchison, John O'Connor, Lloyd G. Copeman, Henry Wise Wood, S. W. Rushmore, William H. Smyth, Rueben Benjamin, and others of similar prominence and reputation. An idea of the inventive activity of these men can be obtained from the fact that they obtained on the average 39.3 patents. They were first requested to give the occupation of their father. The results are given in Table I.*

Table I shows that about one-third of the inventors had fathers engaged in the professions, 35.5 per cent of the fathers were engaged in commercial activities, 16.2 per cent were skilled

*TABLE I—OCCUPATION OF THE FATHERS OF 710 INVENTORS

Occupation	Number	Per Cent	Occupation	Number	Per Cent
Professional	231	33.3	Commercial	246	35.5
Engineer	46		Merchant	129	
Attorney	31		Manufacturer	62	
Educator	26		Superintendent	27	
Physician	25		Contractor	19	
Musician and Artist	24		Salesman	9	
Clergyman	23		Skilled labor	112	16.2
Public Official	20		Trades	80	
Banker	13		Mechanic	32	
Chemist and Pharmacist	12		Agriculture	104	15.0
Mathematician	6		Farmer	104	
Publisher, Writer	5		No answer	17	

laborers, 15 per cent were farmers. The occupation of the fathers shows that the inventors of this study come from a decidedly superior type of stock. It may be, of course, that the homes of engineers, physicians, attorneys, clergymen and educators are extremely favorable for the expression of originality to the child as well as affording excellent opportunities for study and schooling.

The Army tests have shown that there are distinct differences in the intelligence of the various occupational groups. The professional groups such as doctors, engineers, lawyers, were at the top in scores made; whereas laborers, farmers, painters, traders, were at the bottom. According to Ellis:

> The Army tests were given to adults, mostly young, who were actually engaged in particular occupations. Very similar results, however, have been secured by studies made on children classified by the occupation of their parents. Studies along this line are rather numerous, but a few will be given to illustrate the results. Duff and Thomson[7] tested 13,419 children, 11 and 12 years of age, in England and classified these according to parental occupation. The average I. Q. for children of the professional classes was 112.2 and for laborers 96. Other occupational groups were between these. Pressey and Ralston[13] tested all the available children from 10 to 14 years of age in a town of 12,000, these being 548 in number, and found that 85 per cent of the children of professional men were above the median of the total group in comparison with 68 per cent of the children of artisans, and 39 per cent of the children of laborers. Dexter[6] tested children in grades 1 to 8 in 13 ward schools in Madison, Wisconsin, and determined the average scores for occupational groups. The correlation between this determination and the results of the Army tets was found to be .79. Haggerty and Nash[11] studied the intelligence of children according to occupation of parents and found in the elementary school the same general results as those already described. In the high school the differences were not pronounced, but great differences were found in the amount of selection occuring before high school. A much smaller per cent of the children of the laboring classes attend high school. A rather large difference was found between the children of miners and those of lawyers. None of the former group attained the median attained by the latter group. Generally speaking, there is, of course, much overlapping between the various groups.[9]

If we are to accept the general results of these studies we must then conclude that the inventors of our study are highly intelligent as they come from the upper groups of the population.

The inventors of this study were also asked to state whether their children showed any evidence of inventiveness. The results are given in Table II.*

Table II shows that 66.4 per cent of the inventors having adult children indicated that their children showed some evidence of inventiveness. It is difficult to determine just what standards were used in answering this question but the test used generally was one of originality and individuality in their activities.

A study was also made of the inventiveness of the relatives of the inventors. The results are given in Table III together with the answers reported for the inventiveness of the children of the inventors.

Nearly forty per cent of the inventors had relatives who were inventors. These inventors had 143 children who showed evidences of inventiveness or 48.3 per cent of all the children reported as showing inventiveness by 710 inventors. Table III appears to show that the nearer the relatives who are inventors the more the children tend to show inventiveness. Thus there were 189 inventors who had direct inventive ancestors and had 102 inventive children and 13 non-inventive children. There were 91 inventors who had 41 inventive children and 19 non-inventive children. In other words for each 1.9 inventors who had direct inventive an-

***TABLE II—INVENTIVENESS OF THE CHILDREN OF INVENTORS**

	Number
Inventive	296
Not inventive	151
No children	96
Too young	88
No answers	79
Total	710

cestors there was one inventive child, whereas 2.9 inventors who had more remote inventive relatives were required for one inventive child. Likewise it took 14.5 inventors having direct inventive ancestors to produce one non-inventive child, against 4.8 inventors who had more remote inventive relatives.

A comparison of all inventors who had inventive relatives with inventors who had no inventive relatives also shows decided differences in the inventiveness of their children. Thus there are 1.9 inventors having inventive relatives for each inventive child, against 2.8 inventors having no inventive relatives for each inventive child. There are also 8.7 inventors having inventive relatives for each non-inventive child, against 3.6 inventors having no inventive relatives for each non-inventive child.

Racial Heredity and Inventiveness

The problem of individual heredity of inventiveness also raises the question whether there is such a thing as racial heredity of inventiveness. A statistical study of the geographic distribution of inventors shows that inventors are found in greater numbers in proportion to the population in certain regions both in the United States and Europe than in other regions. Whether this is due to economic conditions or the racial stock is difficult to determine. The sharp differences in distribution might have been caused by shifts in the population, the more able, progressive and intelligent members of the population moving to more favorable regions. This may be a plausible explanation for the distribution in the United States. As to racial distributions there may be race degeneration, unfavorable geographic conditions which prevent industrialization. These possible causes, however, are mere conjectures.

As an example of variation in inventiveness the case of China may be cited. It is conceded by all students that China has developed in the past an extremely high type of civilization. It unquestionably produced a very high grade of inventive genius. In this connection it may be useful to enumerate some of the inventions listed by a Chinese engineer, Chung-Yee Wang:

> The compass; Records show that Chow Kung in the Chow Dynasty, about 1122 B. C., used a kind of wagon equipped with an instrument that pointed always toward the north.
>
> Paper was first made by Tsai Lun, out of tree fibers, rags, and hemp, during the

TABLE III—INVENTIVE RELATIVES OF INVENTORS AND INVENTIVENESS OF THE CHILDREN OF THE INVENTORS

Relationship	Totals	Inventiveness of children of inventors				
		Inventive	No. of Inventors Per Child	Not Inventive	No. of Inventors Per Child	No Answer
Ancestors	189	102	1.9	13	14.5	74
Father	108	58		2		48
Mother	7	4		1		2
Grandparents	74	40		10		24
Other relatives	91	41	2.2	19	4.8	31
Uncles	29	13		2		14
Cousins	22	10		7		5
Brothers	34	15		10		9
Other remote relatives	6	3				3
Sub. Total	280	143	1.9	32	8.7	105
No relatives	430	153	2.8	119	3.6	158
Total	710	296		151		263

Dynasty of Eastern Han, the early part of the first century.

Printing; it has been mentioned that Fung To originated the art of stereotyped wooden plates about the year 932 A. D., but later investigation made by the sinologue, Stanislas Julien has shown that the invention actually dated from the year 593. A record of this period proves this: "It was decreed that drawings and unpublished texts should be collected and engraved on wood for publication."

Glass was first manufactured by Pun Fang about the early part of the second century. It is recorded that he had a piece carved with 130 designs.

Seismograph; an instrument, resembling perhaps the present day seismograph, was invented by Chang Heng in the first century, during the Han Dynasty, which could record any slight earthquake not perceptible by human senses.

Metals; In Tai Hao's time (2852-2737 B. C.) metallic coin was already in circulation. The inventive genius of the ancient Chinese can nowhere be more explicitly shown than in the art of making alloys. An alloy, similar to German silver, under the name of Pait' ong, was obtained by fusing "red steel" with arsenic. The manufacture by the ancients of gongs and tom toms, with their chemical composition has been determined.

Medicine; We may laugh at some of the ridiculous prescriptions of Chinese doctors; but I believe that there is a great deal of Chinese medicine that is both useful and illuminating when viewed in the light of occidental medical science. The Chinese anesthetic, known as Ma Fat powder, a sort of hashish, was discovered by the famous Chinese surgeon, Hwa To, who lived in the early part of the second century, during the Eastern Han Dynasty. An old Chinese text tells us that Hwa To administered the medicine to his patients to render them unconscious before being operated upon. This happened long before ether or chloroform was discovered in Europe.

Recently two experimenters at the Rockefeller Medical Institute in New York City obtained a white secretion which they have named Bufin, by stimulating the paratid gland of the toad by means of electricity. Its physiological action is almost similar to that of digitalis. This is merely a re-discovery of a medicine long known in China. The identical white secretion is obtained today by the Chinese by touching the biggest wart-like swelling just behind the eye of a toad with a hot iron. The secretions thus obtained from many toads are allowed to evaporate slowly to a powder, which is now mainly used as a heart remedy.[12]

Why has the inventive genius of China disappeared and why has she declined in all other social aspects? The answer is possibly ancestor worship, the reign of conservatism and blind prejudice for many centuries with the resultant deterioration of ideals. "For example, the premium of the old state-examination system of China put upon the writings of certain thinkers who lived long before our era tended to shackle the original minds of each generation. The embryo Pasteur or Edison was so intimidated by the universal opinion that wisdom died with the sages, that he could bring forth nothing. Thus the social atmosphere lost the stimulating ozone it had in the old inspiring days when the Chinese invented gunpowder, block-printing, banknotes, porcelain, the compass, the compartment boat and the taxicab."[14] The geneticist might postulate changes in the distribution of the genes of the Chinese people, as the cause of the change.

The data presented in this paper indicate that the transmission of inventive ability involves numerous factors which at present are difficult to evaluate. Economic and geographic conditions and social ideals may be the chief causes for the decided differences in the geographic distribution of inventiveness rather than any innate hereditary abilities. Further study is necessary before this question can be satisfactorily answered.

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BOOKS are acknowledged in this column as received, and such acknoweldgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the JOURNAL *will be reviewed in later numbers.*

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THE HEREDISCOPE AT THE NATIONAL DAIRY SHOW

Guernsey Breeders' Journal for November 1, 1930, said of the "Breeding School":

In the lecture room of the school the bureau's breeding experts are explaining, by charts and a device known as the herediscope, the Mendelian principles of breeding which the bureau is applying to its work.

There is intense interest in this school. Its lecture room and the room where the Huntley cattle are exhibited, are being visited by hundreds of people. Deans, professors, instructors, students, and extension people of the state colleges of agriculture, breeders, dairy farmers, veterinarians, journalists, and others are attending the lectures. They will go out and carry the work of the school to the people with whom they work, and thus help the cause of breeding up the Nation's dairy cattle.

Since the Dairy Show extension workers in *23 states have ordered 243 Herediscopes*. "Breeding Schools" patterned after that at the Dairy Show have been given in a number of states and have been enthusiastically attended.

The Herediscope is sold only by

THE AMERICAN GENETIC ASSOCIATION

PRICE $3 IN U. S.